US007284530B2

(12) United States Patent
Nagasaki et al.

(10) **Patent No.: US 7,284,530 B2**

(45) **Date of Patent: Oct. 23, 2007**

(54) **LEAK DETECTOR FOR FUEL VAPOR PURGE SYSTEM**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 65 days.

(21) Appl. No.: **11/264,152**

(22) Filed: **Nov. 2, 2005**

(65) **Prior Publication Data**

US 2006/0090553 A1 May 4, 2006

(30) **Foreign Application Priority Data**

Nov. 2, 2004 (JP) 2004-318645

(51) **Int. Cl.**
F02B 77/08 (2006.01)

(52) **U.S. Cl.** .... **123/198 D**; 123/520; 73/118.1

(58) **Field of Classification Search** .... 123/198 D, 123/520, 519, 518, 516; 73/118.1, 40.5, 73/49.7

See application file for complete search history.

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(57) **ABSTRACT**

A suction pump introduces negative pressure into a reference-pressure-detecting portion. A driving voltage V of the suction pump is adjusted in such a manner that pressure Pr in the reference-pressure-detecting portion is within a target pressure range. When the pressure Pr is brought into the target pressure range, the driving voltage V of the suction pump is stored as a first driving voltage V**1** and the pressure Pr is stored as a reference pressure Pr. When pressure detection and leak detection process are conducted, the suction pump is driven at the first driving voltage V**1** to introduce the negative pressure. The computer compares the pressure Pr with a leak determination value to determine whether a leak exists.

12 Claims, 10 Drawing Sheets

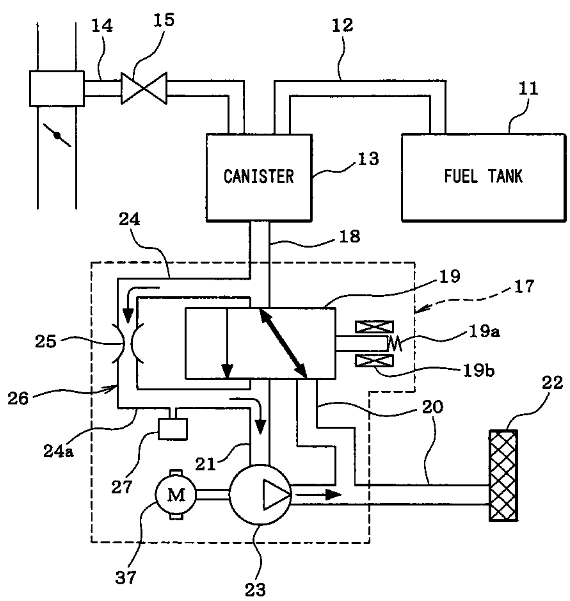


FIG. 1

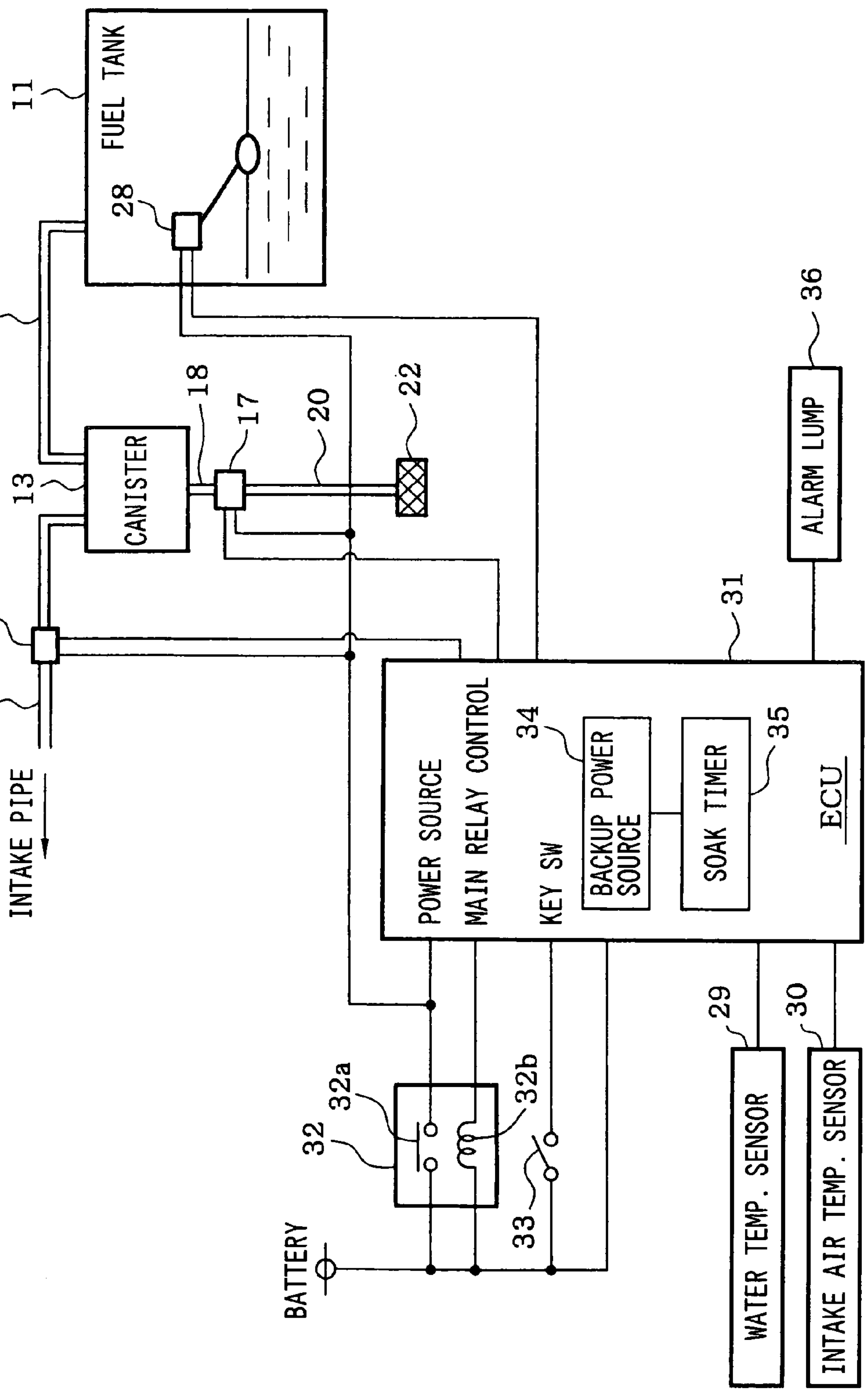

FUEL TANK
11
28
12
CANISTER
13
18
17
20
22
15
14
INTAKE PIPE
ALARM LUMP
36
31
POWER SOURCE
MAIN RELAY CONTROL
KEY SW
34
BACKUP POWER SOURCE
SOAK TIMER
35
ECU
32
32a
32b
33
BATTERY
29
WATER TEMP. SENSOR
30
INTAKE AIR TEMP. SENSOR

FIG. 2

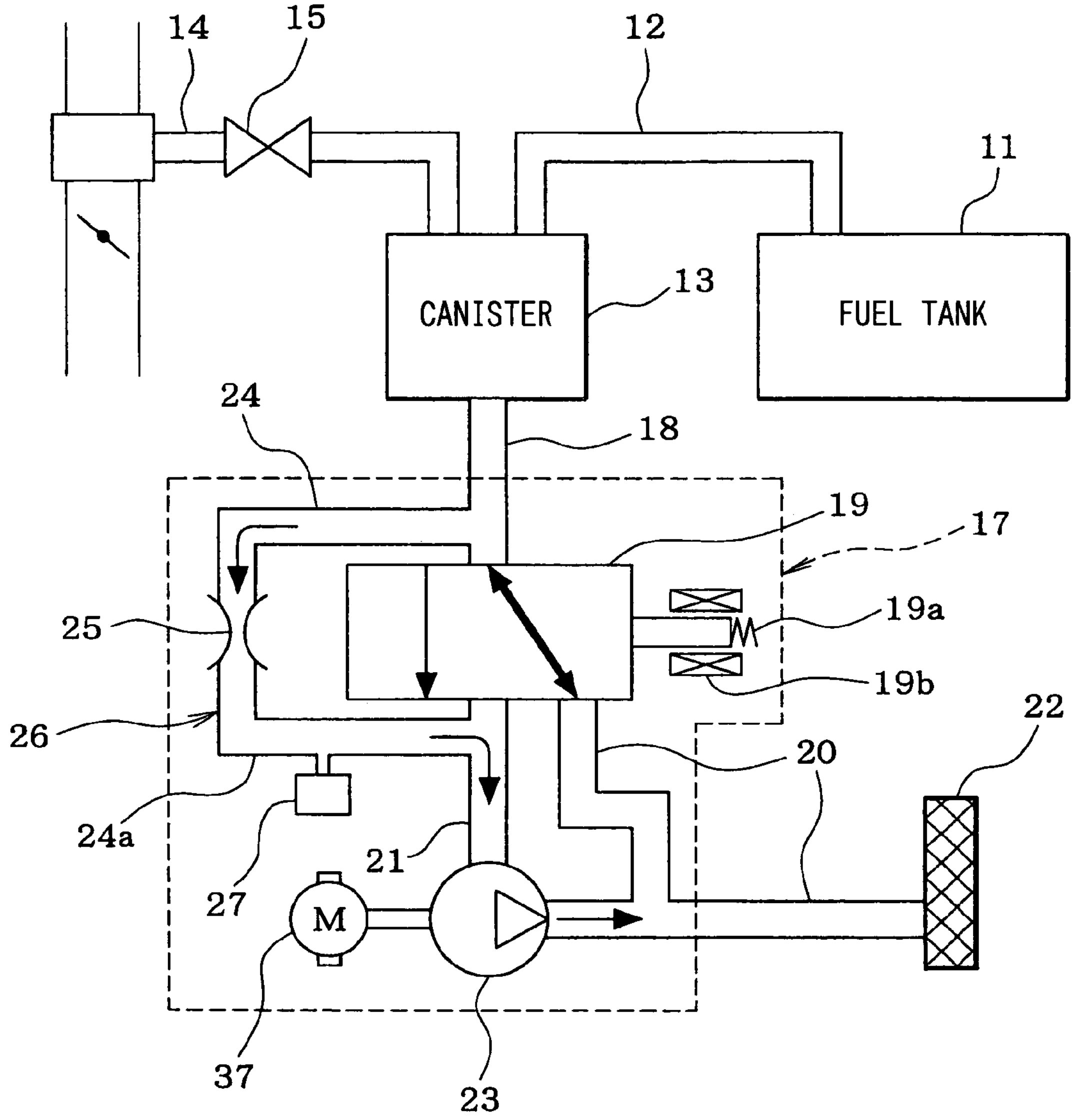

14
15
12
11
CANISTER
13
FUEL TANK
24
18
19
17
25
19a
19b
26
20
22
24a
27
21
27
M
37
23

FIG. 3

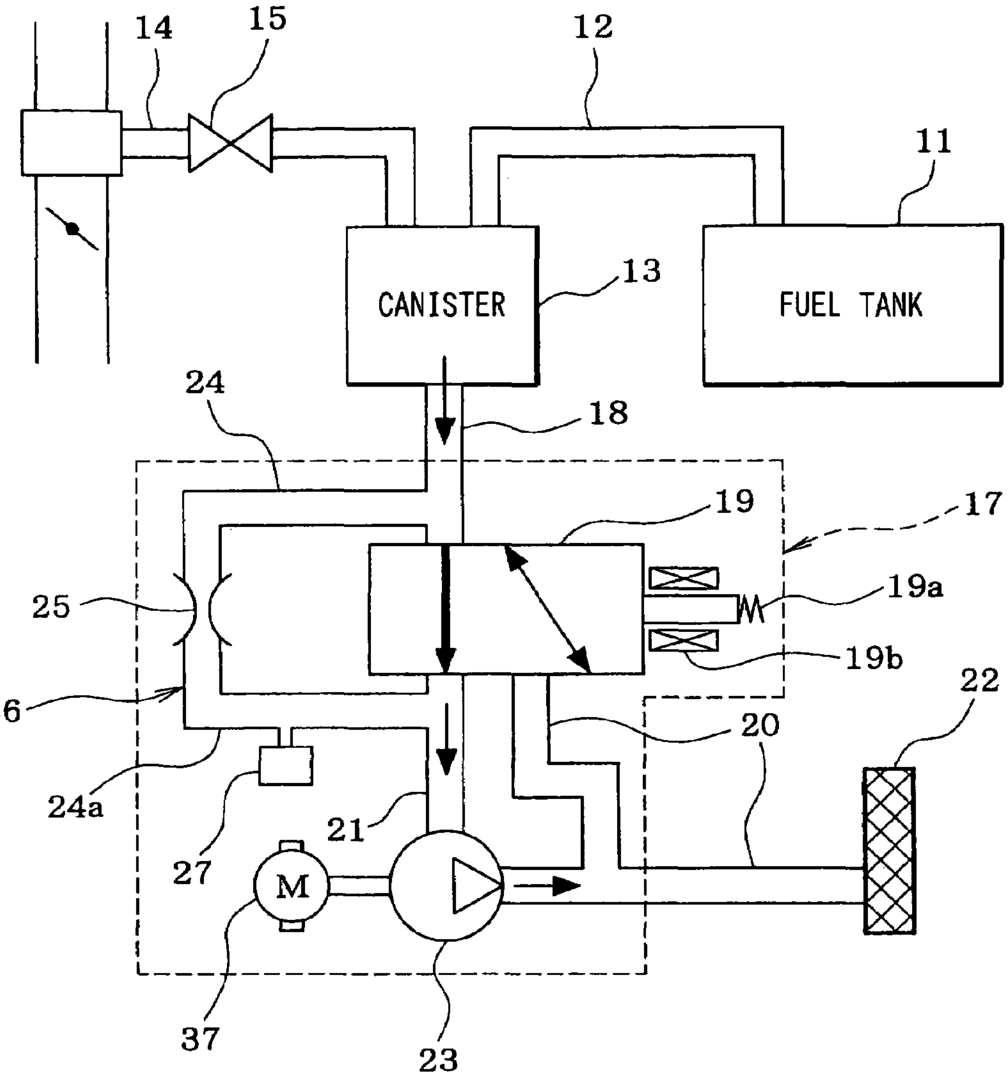

14
15
12
11
CANISTER
13
FUEL TANK
24
18
19
17
25
19a
19b
26
22
20
24a
27
21
M
37
23

FIG. 4

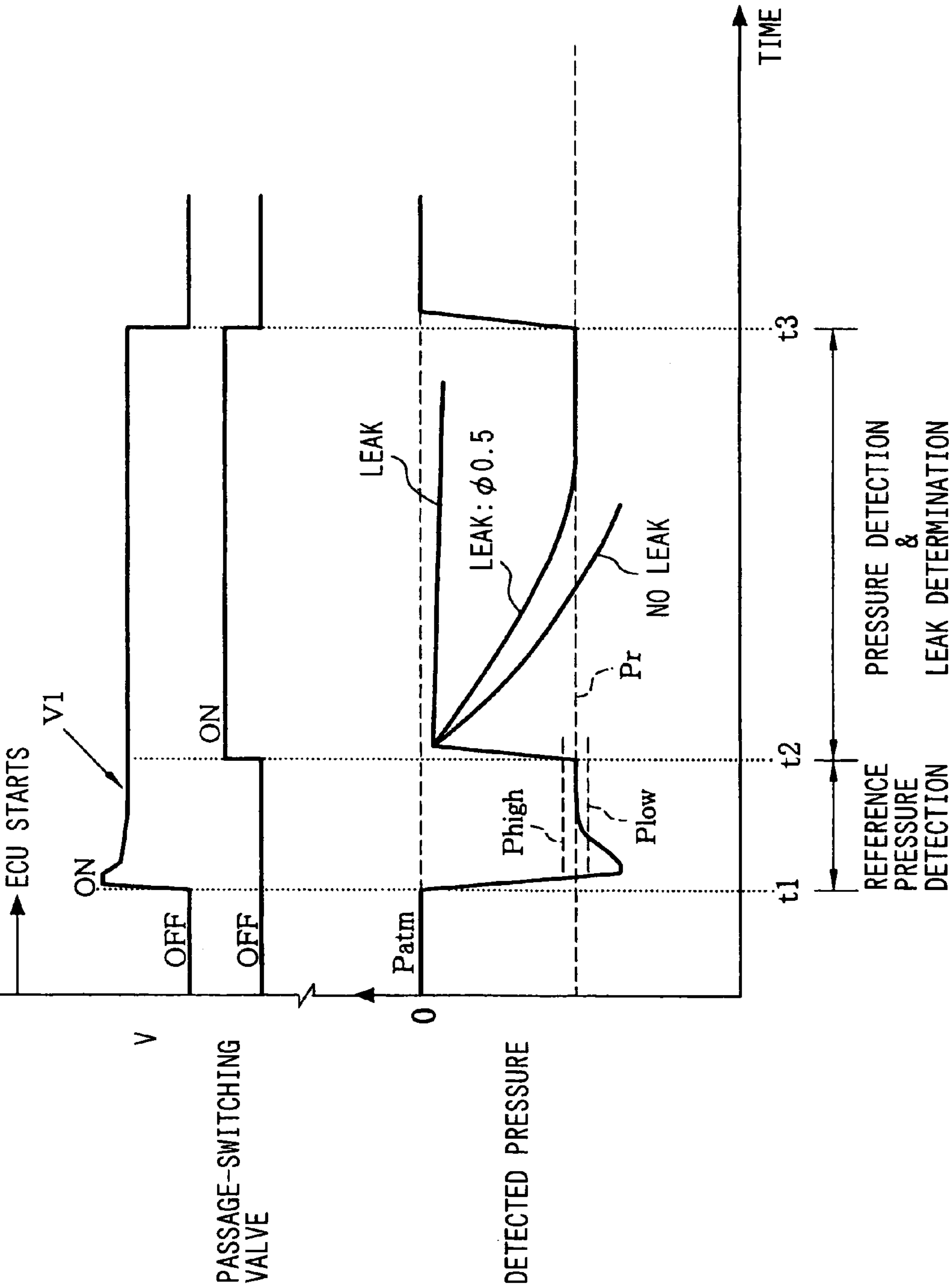
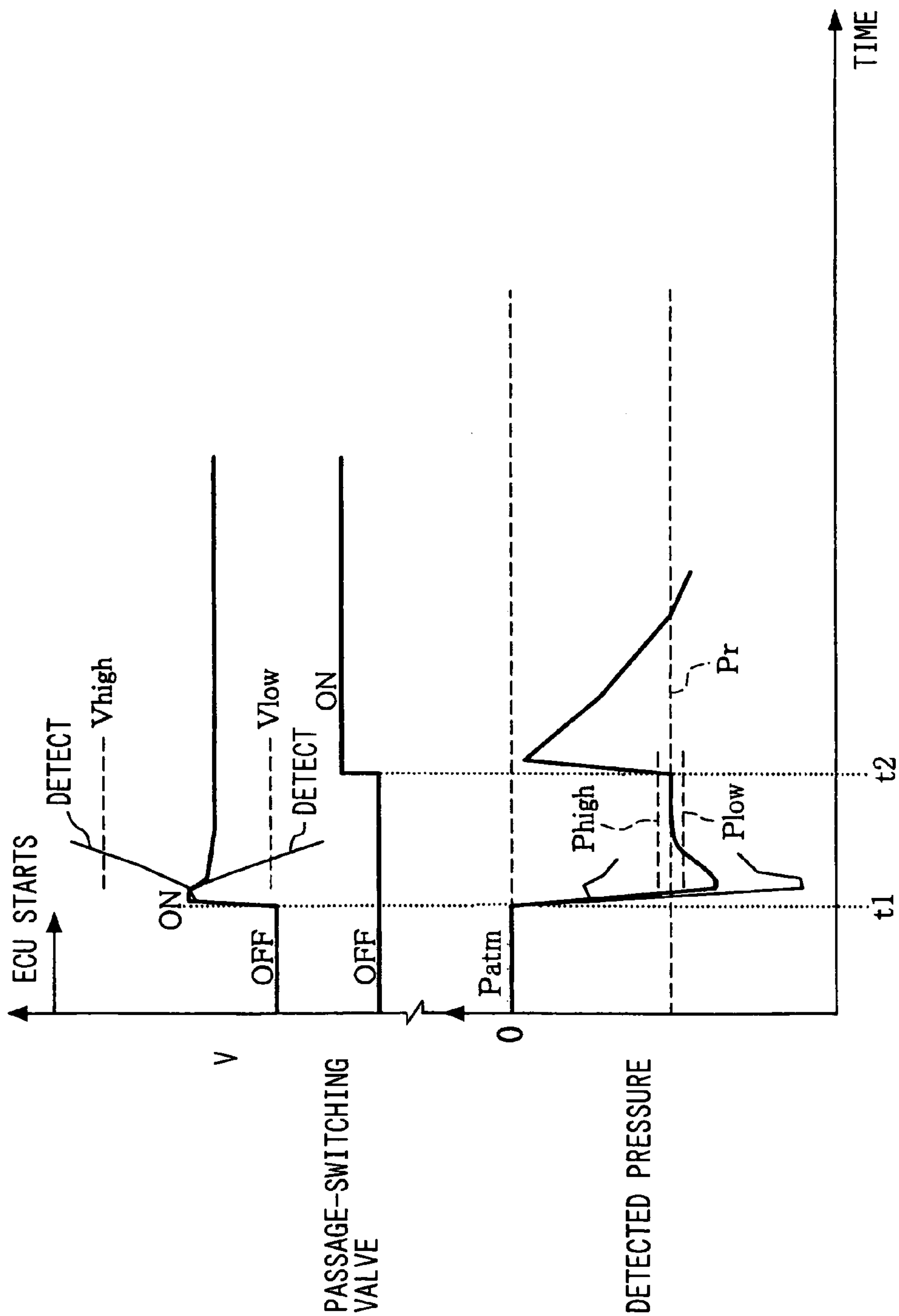

ECU STARTS
V1
V
ON
OFF
ON
OFF
PASSAGE-SWITCHING VALVE
DETECTED PRESSURE
0
Patm
Phigh
Plow
Pr
LEAK
LEAK: φ0.5
NO LEAK
TIME
t1
t2
t3
REFERENCE PRESSURE DETECTION
PRESSURE DETECTION & LEAK DETERMINATION

FIG. 5



ECU STARTS
DETECT
Vhigh
Vlow
DETECT
ON
OFF
V
PASSAGE-SWITCHING VALVE
OFF
ON
Patm
0
DETECTED PRESSURE
Phigh
Plow
Pr
t1
t2
TIME

FIG. 6

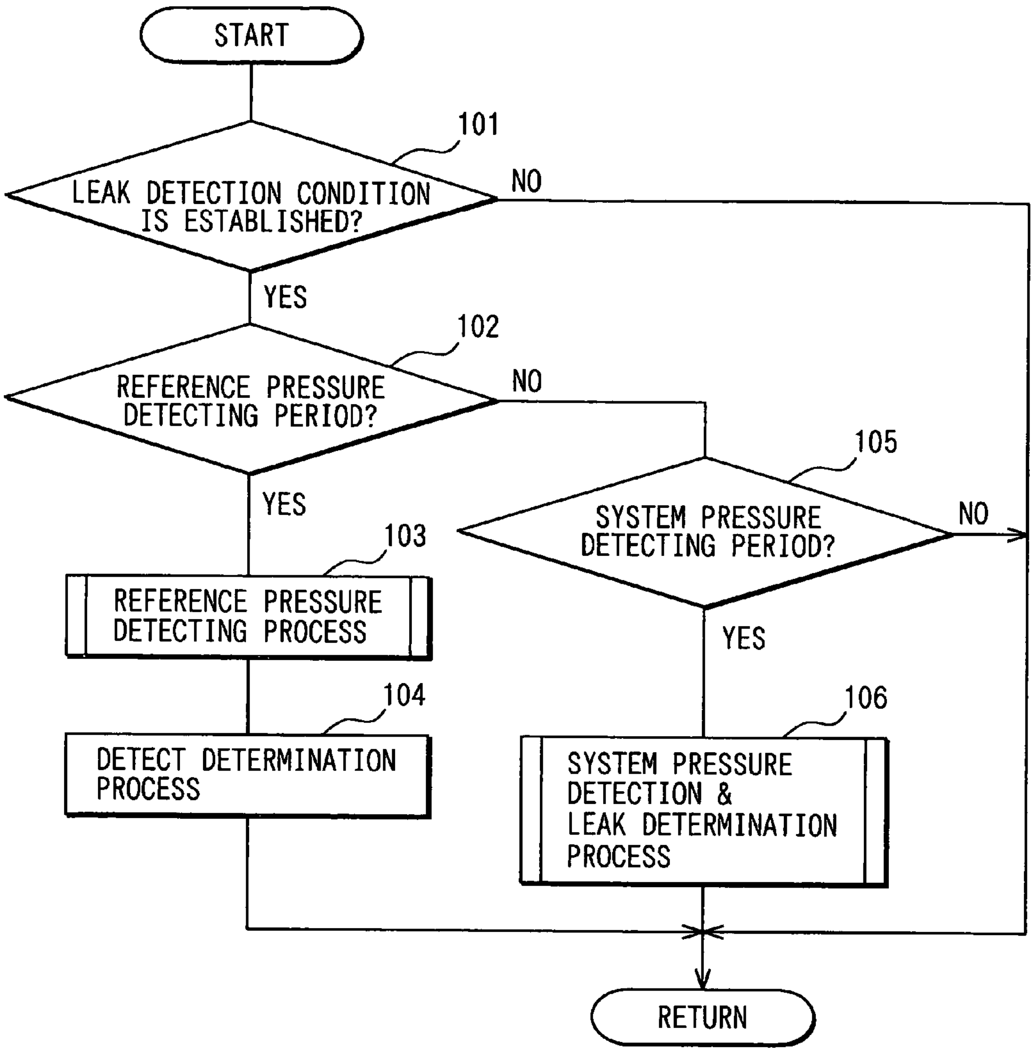

START
LEAK DETECTION CONDITION IS ESTABLISHED?
101
NO
YES
REFERENCE PRESSURE DETECTING PERIOD?
102
NO
YES
REFERENCE PRESSURE DETECTING PROCESS
103
DETECT DETERMINATION PROCESS
104
SYSTEM PRESSURE DETECTING PERIOD?
105
NO
YES
SYSTEM PRESSURE DETECTION & LEAK DETERMINATION PROCESS
106
RETURN

FIG. 7

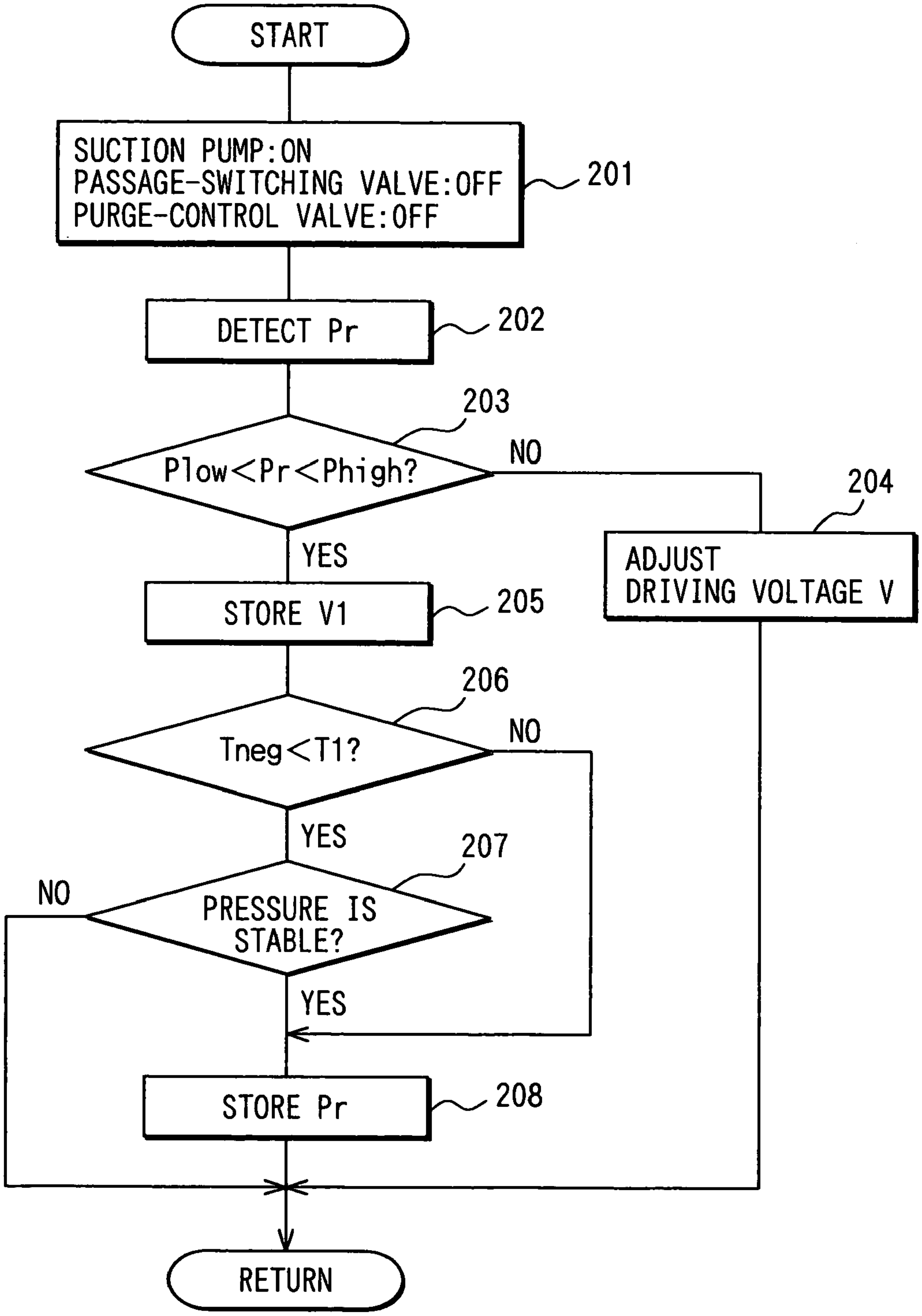

START
SUCTION PUMP:ON
PASSAGE-SWITCHING VALVE:OFF
PURGE-CONTROL VALVE:OFF
201
DETECT Pr
202
203
Plow<Pr<Phigh?
NO
204
ADJUST
DRIVING VOLTAGE V
YES
STORE V1
205
206
Tneg<T1?
NO
YES
207
NO
PRESSURE IS
STABLE?
YES
STORE Pr
208
RETURN

FIG. 8

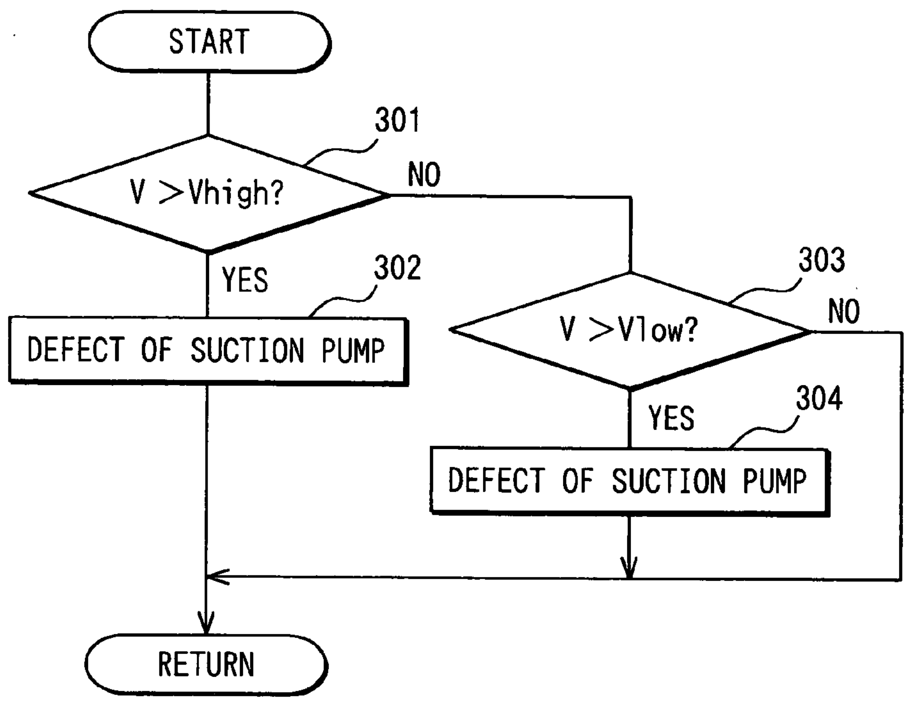

START
301
V >Vhigh?
NO
YES
302
DEFECT OF SUCTION PUMP
303
V >Vlow?
NO
YES
304
DEFECT OF SUCTION PUMP
RETURN

FIG. 9

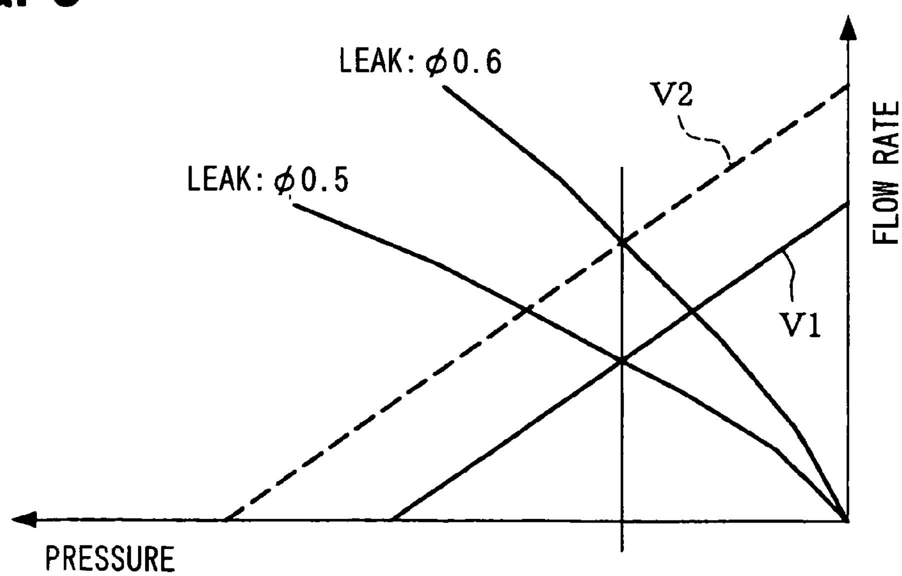

LEAK: φ0.6
V2
LEAK: φ0.5
FLOW RATE
V1
PRESSURE

FIG. 10

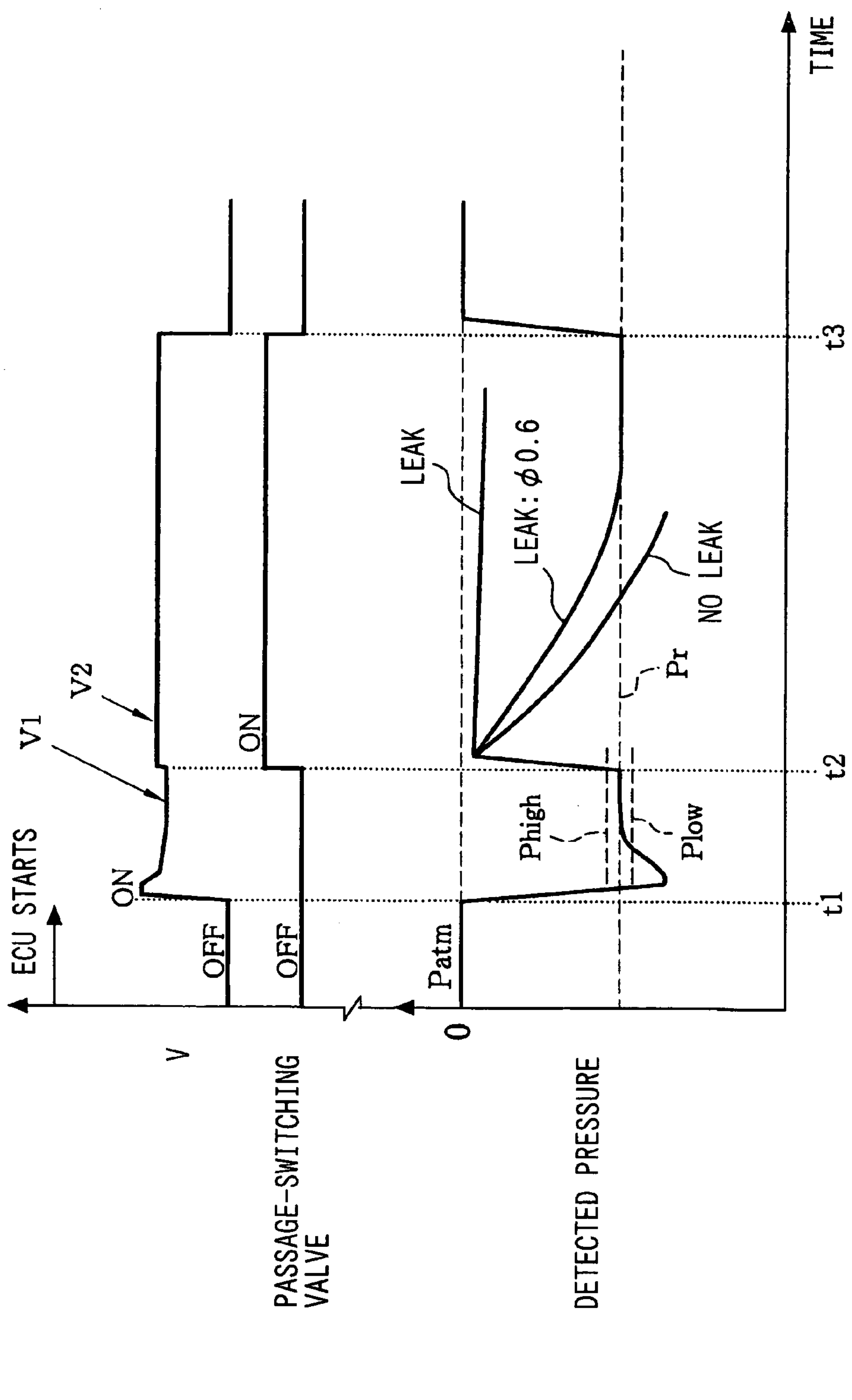

ECU STARTS
V
ON
OFF
V1
V2
PASSAGE-SWITCHING VALVE
ON
OFF
DETECTED PRESSURE
0
Patm
Phigh
Plow
Pr
LEAK
LEAK: φ0.6
NO LEAK
t1
t2
t3
TIME

FIG. 11

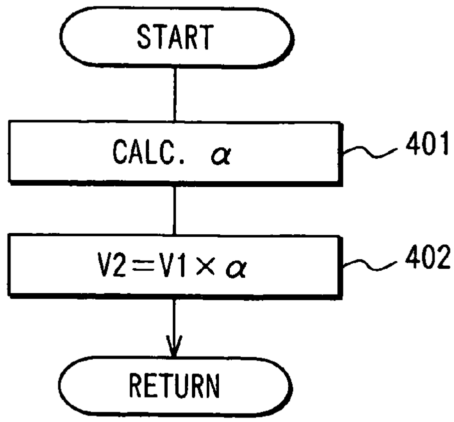
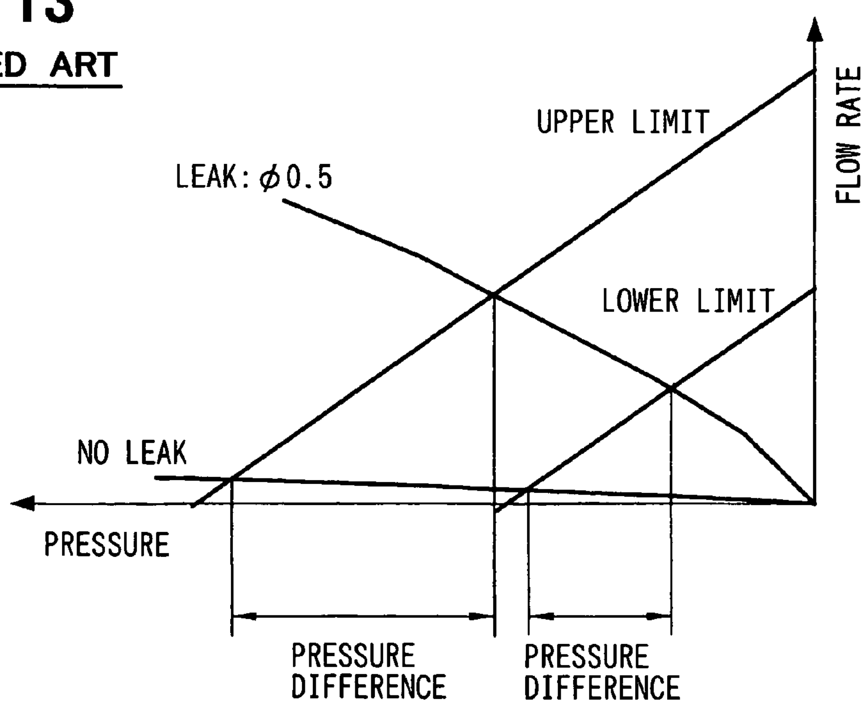


FIG. 12

SECOND APERTURE (mm)	0.4	0.5	0.6	0.7
α	0.7	1.0	1.4	1.9

FIG. 13
RELATED ART



LEAK DETECTOR FOR FUEL VAPOR PURGE SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

This application is based on Japanese Patent Application No. 2004-318645 filed on Nov. 2, 2004, the disclosure of which is incorporated herein by reference.

1. Field of the Invention

The present invention relates to a leak detector for fuel vapor purge system. The fuel vapor purge system introduces fuel vapor generated in a fuel tank into an intake pipe of the internal combustion engine. The leak detector determines whether a leak exists in the fuel vapor purge system.

2. Background of the Invention

The fuel vapor purge system includes a canister communicated to a fuel tank and a purge-control vale disposed between the canister and the intake pipe. The canister absorbs the fuel vapor which is generated in a fuel tank. When the purge-control valve is opened, the fuel vapor absorbed in the canister is introduced into the intake pipe by intake pressure which is negative pressure, so that the fuel vapor is prevented from leaking into atmosphere. If the fuel vapor purge system has a leakage hole therein, the fuel vapor leaks into the atmosphere. Thus, it is important to detect a leak in the fuel vapor purge system as soon as possible.

JP-05-125997A (U.S. Pat. No. 5,317,909) shows a conventional leak detector in which a purge-control valve is opened to introduce negative pressure into a fuel tank, and then the purge-control valve is closed to close a fuel vapor purge system including the fuel tank and a canister. Under such a condition, variation in pressure of the fuel vapor purge system is measured to be compared with a leak determining value, so that whether the leak exists in the fuel vapor purge system is determined. However, this leak detector cannot detect a minor leak and size of the leak precisely.

JP-2000-205056A shows another conventional leak detector in which an electric motor introduces positive pressure into a reference-pressure detecting portion to detect a reference pressure which is restricted by a reference orifice. And then, the electric motor introduces positive pressure into the fuel vapor purge system to detect the pressure in the fuel vapor purge system. When the pressure in the fuel vapor purge system are detected, the electric motor is driven by the same voltage as the time when the reference pressure is detected. Comparing the reference pressure with the pressure in the fuel vapor purge system, the minor leak and the size of the leak can be detected. When the positive pressure is introduced into the reference-pressure detecting portion, the electric motor is driven at voltage **V1**. When the positive pressure is introduced into the fuel vapor purge system, the electric motor is driven at voltage **V2**, which is higher than the voltage **V1**, for a certain time period, and then the electric motor is driven at the voltage **V1** again.

The electric pump has a variation in characteristic thereof due to production tolerance and aging. The characteristic is, for example, a relationship between a driving voltage and a discharge amount. In the leak detector shown in JP-2000-205056A, the electric pump is always driven at the voltage **V1** without considering the variation of the characteristic. Thus, the positive pressure introduction condition (for example, discharge amount of the electric pump) varies when the reference pressure and the pressure in the system are detected.

The variation in the positive pressure introduction condition varies the reference pressure, so that an accuracy of leak detection varies. Besides, a case in which a suction pump is used will be explained referring to FIG. **13**. In a fuel vapor purge system in which the characteristic of the suction pump is brought to be close to a lower limit, the discharge amount of the suction pump is decreased. Thus, the pressure difference between a case that a leak exists and a case that no leak exists is decreased to deteriorate the accuracy of leak detection. On the other hand, in the fuel vapor system in which the characteristic of the suction pump is brought to be close to an upper limit, the discharge amount of the suction amount is increased. The negative pressure at the time of detecting the pressure in the fuel vapor purge system is increased. That is, the pressure difference relative to the atmospheric pressure is increased. Thus, the inner pressure applied to the fuel vapor purge system is increased to deteriorate durability thereof.

SUMMARY OF THE INVENTION

The present invention is made in view of the foregoing matter and it is an object of the present invention to provide a leak detector for a fuel vapor purge system which is able to stabilize a pressure introduction condition at the time of detecting a leak without being affected by a variation of characteristic of a pressure introduction means. The leak detector is able to enhance accuracy of the leak detection and durability thereof.

According to the present invention, a leak detector includes a pressure introducing means, a reference-pressure-detecting portion provided with a reference aperture, a switching mean for switching between a passage for introducing the pressure into the reference-pressure-detecting portion and a passage for introducing the pressure into the fuel vapor purge system, and a leak determination means.

The leak determination means detects a reference pressure information representing a reference pressure adjusted by the reference aperture or a correlating information of the reference pressure. The leak determination means detects a system pressure information representing a system pressure in the fuel vapor purge system or a correlating information of the system pressure. And then, the leak determination means determines whether a leak exists by comparing the reference pressure information with the system pressure information. The leak determination means adjusts a control value of the pressure introducing means in such a manner that the reference pressure information becomes the target condition to set the control value as a first control value, and drives the pressure introducing means at the first control value during a detecting operation of the system pressure information.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features, and advantages of the present invention will become more apparent from the following detailed description made with reference to the accompanying drawings, in which like parts are designated by like reference number and in which:

FIG. **1** is a schematic view showing a fuel vapor purge system according to a first embodiment;

FIG. **2** is a schematic view showing a leak check model in a situation that a reference pressure detecting process is conducted;

FIG. **3** is a schematic view showing a leak check model in a situation that a system pressure detecting process is conducted;

FIG. **4** is a time chart showing a leak detecting according to the first embodiment;

FIG. **5** is a time chart showing a defect determination process;

FIG. **6** is a flowchart showing a main control process for leak detection;

FIG. **7** is a flowchart showing a reference pressure detecting process;

FIG. **8** is a flowchart showing a defect determination process;

FIG. **9** is a graph for explaining a leak detection according to a second embodiment;

FIG. **10** is a time chart showing a leak detection according to a second embodiment;

FIG. **11** is a flowchart showing a second voltage calculation process;

FIG. **12** is a table schematically showing a table of a correction coefficient α; and

FIG. **13** is a graph for explaining a problem in a conventional apparatus.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the present invention will be described hereinafter with reference to the drawings.

First Embodiment

Referring to FIGS. **1** to **8**, a first embodiment is described hereinafter.

FIG. **1** is a schematic view of a fuel vapor purge system. A canister **13** is connected to a fuel tank **11** through an evaporation passage **12**. The canister **13** accommodates an absorber such as an activated carbon (not shown) which absorbs fuel vapor generated in the fuel tank **11**.

A purge passage **14** connects the canister **13** with an intake pipe of the engine (not shown) in order to purge the absorbed fuel vapor from the canister **13** and introduce the purged fuel vapor into the intake pipe. The purge passage **14** has a purge-control valve **15** in order to control the amount of purged fuel vapor which is introduced into the intake pipe. The purge-control valve **15** is a normally closed valve driven by duty-control.

A leak check module **17** (pressure introduction detecting apparatus) is connected to the canister **13**. As shown in FIGS. **2** and **3**, the leak check module **17** has a canister-communicating passage **18** which is connected to the canister **13**. The canister-communicating passage **18** is connected to an atmosphere-communicating passage **20** and a negative-pressure-introducing passage **21** through a passage-switching valve **19** (switching means). The atmosphere-communicating passage **20** is opened to the atmosphere through a filter **22**. The negative-pressure-introducing passage **21** is connected to the atmosphere-communicating passage **20** through an electric suction pump **23** (pressure introducing means). A motor **37** drives the electric suction pump **23** which introduces the purged fuel vapor from the negative-pressure-introducing passage **21** to the atmosphere-communicating passage **20**.

The passage-switching valve **19** is an electromagnetic valve which is switched between an atmosphere-releasing position (shown in FIG. **2**) and a negative-pressure introducing position (shown in FIG. **3**). The passage-switching valve **19** connects the canister-communicating passage **18** with the atmosphere-communicating passage **20** at the atmosphere-releasing position, and connects the canister-communicating passage **18** with the negative-pressure-introducing passage **21** at the negative-pressure introducing position. When a solenoid **19***b* is deenergized, the passage-switching valve **19** is biased to the atmosphere-releasing position by a spring **19***a*, and when energized, the passage-switching valve **19** is moved to the negative-pressure introducing position.

A bypass passage **24** is connected to the canister-communicating passage **18** and the negative-pressure-introducing passage **21** in such a manner as to bypass the passage-switching valve **19**. The bypass passage **24** includes a reference orifice **25** (reference aperture) of which diameter is a reference leak diameter (for example, 0.5 mm). The reference orifice **25** and a passage **24***a* connecting the reference orifice **25** with the negative-pressure-introducing passage **21** form a reference-pressure-detecting portion **26**. A pressure senor **27** is provided in the reference-pressure-detecting portion **26**.

As shown in FIG. **2**, when the passage-switching valve **19** is at the atmosphere-releasing position and the purge-control valve **15** is closed, the bypass passage **24** (reference-pressure-detecting portion **26**) is opened to the atmosphere through the canister-communicating passage **18** and the atmosphere-communicating passage **20**. The pressure sensor **27** detects the pressure in the reference-pressure-detecting portion **26** as atmospheric pressure.

When the suction pump **23** is driven under this situation, the pressure in the reference-pressure-detecting portion **26** becomes negative pressure by the reference orifice **25**. At this time, the pressure senor **26** detects the pressure in the reference-pressure-detecting portion **26** as a reference pressure which corresponds to diameter of the reference orifice **25**.

When the passage-switching valve **19** is at the negative-pressure introducing position and the purge-control valve **15** is closed as shown in FIG. **3**, the fuel vapor purge system which is comprised of the fuel tank **11**, the evaporation passage **12**, the canister **13** and the purge passage **14** is tightly closed. The reference-pressure-detecting portion **26** is connected to the fuel vapor purge system through the negative-pressure-introducing passage **21** and the canister-communicating passage **18**, so that the pressure sensor **27** can detects the pressure in the fuel vapor purge system.

When the suction pump **23** is driven under the situation in which the fuel vapor purge system is closed, the fuel vapor in the fuel vapor purge system is expelled into the atmosphere through the canister-communicating passage **18**, the passage-switching valve **19**, the suction pump **23**, and the atmosphere-communicating passage **20**, so that the negative pressure is introduced into the fuel vapor purge system.

As shown in FIG. **1**, a fuel level sensor **28** for detecting amount of fuel in the fuel tank **11** is provided in the fuel tank **11**. A water temperature sensor **29** detecting a coolant temperature, and an intake air temperature sensor **30** detecting an intake air temperature are provided.

Output signals from the sensors are inputted into an electronic control unit (ECU) **31**. The ECU **31** receives main power voltage from a vehicle-mounted battery (not shown) through a main relay **32**.

The main power voltage is supplied to the purge-control valve **15**, the passage-switching valve **19**, the suction pump **23**, the pressure senor **27** and the fuel level sensor **28** through the main relay **32**. A relay coil **32***b* driving a relay contact **32***a* of the main relay **32** is connected to a main relay terminal of the ECU **31**. When the relay coil **32***b* is energized, the relay contact **32***a* is closed to supply the main power voltage to the ECU **31** and the like. When the relay coil **32***b* is deenergized, the relay contact **32***a* is opened to stop supplying of the main power voltage to the ECU **31** and the like.

An ON/OFF signal from an ignition switch **33** is inputted into a key switch terminal of the ECU **31**. When the ignition switch **33** is turned on, the main relay **32** is turned on to supply the main power voltage to the ECU **31** and the like. When the ignition switch **33** is turned off, the main relay **32** is turned off to stop the main power voltage supply.

The ECU **31** includes a backup power source **34** and a soak timer **35** which is operated by means of the backup power source **34**. The soak timer **35** starts to count when the engine is stopped and counts elapsed time since the engine is stopped. In order to detect the leak of the fuel vapor purge system with the engine off, when a predetermined period has passed since the engine is turned off, the main relay **32** is turned on by means of the backup power source so that the main power voltage is supplied to the ECU **31**, the purge-control valve **19**, the suction pump **23**, the pressure sensor **27**, the fuel level sensor, and the like.

The ECU **31** is mainly comprised of a microcomputer executing a fuel injection control program, an ignition timing control program, and a purge control program which are stored in a read only memory (ROM).

Furthermore, the ECU **31** executes processes shown in FIGS. **6** to **8** so that the reference pressure and the pressure in the fuel vapor purge system are compared with each other to determine whether the leak exists.

The leak detection of the fuel vapor purge system executed by the ECU**31** is described hereinafter. As shown in FIG. **4**, at the time of t**1** in which a predetermined period (for example, three to nine hours) has passed since the engine was stopped, the reference pressure detecting operation starts. When the pressure sensor **27** is an absolute pressure sensor, the purge-control valve **15** is closed and the passage-switching valve **19** is brought to be at the atmosphere-releasing position in order that the pressure sensor **27** detects the pressure in the reference-pressure-detecting portion **26** as atmospheric pressure Patm, which is stored in a memory of ECU **31**.

In a reference pressure detecting operation, the purge-control valve **15** is closed, the passage-switching valve **19** is kept at the atmosphere-releasing position, and then the suction pump **23** is driven, so that the negative pressure is introduced into the reference-pressure-detecting portion **26**, as shown in FIG. **2**. A driving voltage V for the suction pump **23** is adjusted in such a manner that the pressure Pr in the reference-pressure-detecting portion **26** is within a target pressure range (lower limit $Plow<Pr<$ upper limit Phigh). When the pressure Pr is brought to be within the target pressure range, the driving voltage V for the suction pump **23** is stored in the memory of the ECU **31** as a first driving voltage V**1**.

At the time of t**2** in which a time period T**1** has passed since the negative pressure started to be introduced into the reference-pressure-detecting portion **26**, it is determined that the negative pressure in the reference-pressure-detecting portion **26** is stable, so that the negative pressure detected by the pressure sensor **27** is stored in the memory of ECU **31** as a reference pressure Pr.

After the reference pressure Pr is detected, a pressure detection and a leak detection in the fuel vapor purge system are started. While the suction pump **23** is driven at the first voltage V**1**, the passage-switching valve **19** is switched into the negative-pressure introducing position to introduce the negative pressure into the fuel vapor purge system as shown in FIG. **3**. Before a time period T**2** is passed, if the pressure Pf in the fuel vapor purge system detected by the pressure sensor **27** is lower than a leak determining value (for example, the reference pressure Pr or a pressure which is smaller than the reference pressure Pr), the computer determines that there is no leak in the fuel vapor purge system. On the other hand, at the time t**3** in which a time period T**2** has passed since the negative pressure was introduced into the fuel vapor purge system, if the pressure Pf is greater than or equal to the leak determining value, the computer determines that there is a leak in the system. If the pressure Pf is close to the reference pressure Pr, it is determined that the leak hole is substantially the same as the reference orifice **25** of which diameter is reference leak diameter (for example, 0.5 mm). If the pressure Pf is greater than the reference pressure Pr, it is determined that the leak hole is larger than the reference orifice.

In the case that computer determines the leak hole exists, an alarm lump **36** is turned on to alert the driver, and the information of defect is stored in a nonvolatile memory such as a backup RAM (not shown) of ECU **31**.

As shown in FIG. **5**, when the driving voltage V of the suction pump **23** is within a normal range ($Plow<Pr<Phigh$), the suction pump **23** and the reference-pressure-detecting portion **26** have no defect. When the driving voltage V is out of the normal range, it is determined that the suction pump **23** and the reference-pressure-detecting portion **26** have defect, so that the leak detection is stopped and the leak detection result is cancelled.

Referring to FIGS. **6** to **8**, the processes that the ECU **31** executes will be described hereinafter.

(Main Control for Leak Detection)

A main process for leak detection shown in FIG. **6** is executed every predetermined time after the ignition switch **33** is turned off and the main relay **32** is turned on by mean of the soak timer **35**. This program corresponds to a leak detecting means.

In step **101**, the computer determines whether a leak detection condition is established. The leak detection condition is established when following four conditions are satisfied.

(1) The battery voltage is higher than a predetermined voltage (for example, 10.5 V).

(2) The coolant temperature and the intake air temperature are higher than a predetermined temperature (for example, 4.4° C.).

(3) The atmospheric pressure Patm is within a predetermine range (for, example, $70\ kPa<Patm<110\ kPa$).

(4) A predetermined period (for example, five hours) has been passed since the ignition switch **33** was turned off.

In the case that the above four conditions are fully satisfied, the leak detection condition is established. In the case that even one of the conditions is not satisfied, the leak detection condition is not established.

When the answer is No in step **101**, the process ends without executing the following steps.

When the answer is Yes in step **101**, the procedure proceeds to step **102** in which the computer determines whether it is in the reference pressure detecting period. When the answer is Yes in step **102**, the procedure proceeds to step **103** in which a reference pressure detecting process shown in FIG. **7** is executed. That is, the suction pump **23** introduces the negative pressure into the reference-pressure-detecting portion **26**, and the driving voltage V of the suction pump **23** is adjusted in such a manner that the pressure Pr in the reference-pressure-detecting portion **26** is within the target pressure range. The adjusted driving voltage V is stored in the memory as the first driving voltage V**1**, and the pressure in the reference-pressure-detecting portion **26** detected by the pressure sensor **27** is stored in the memory as the reference pressure Pr.

Then, the procedure proceeds to step **104** in which a defect determination process shown in FIG. **8** is executed. That is, the computer determines whether the suction pump **23** and the reference-pressure-detecting portion **26** have a defect according to whether the driving voltage V is within the normal range.

When the answer is No in step **102**, the procedure proceeds to step **105** in which the computer determines whether it is in a system pressure detecting period. When the answer is Yes in step **105**, the procedure proceeds to step **106** in which a process for detecting a pressure in the fuel vapor purge system and the leak determination process are executed. That is, the suction pump **23** is driven at the first voltage V**1** to introduce the negative pressure into the fuel vapor purge system. Comparing the pressure Pf in the fuel vapor purge system with the leak determination pressure, the computer determines whether the leak exists and determines the size of the leak.

(Reference Pressure Detecting Process)

A reference pressure detecting process shown in FIG. **7** is a subroutine executed in step **103** of the main process shown in FIG. **6**. In step **201**, while the purge-control valve **15** is closed and the passage-switching valve **19** is at the atmosphere-releasing position, the suction pump **23** is driven in order to introduce the negative pressure into the reference-pressure-detecting portion. Then, the procedure proceeds to step **202** in which the pressure Pr in the reference-pressure-detecting portion **26** is detected by the pressure sensor **27**.

Then, the procedure proceeds to step **203** in which the computer determines whether the pressure Pr in the reference-pressure-detecting portion **26** is within the target pressure range (Plow<Pr<Phigh). When the answer is No in step **203**, the procedure proceeds to step **204** in which the driving voltage V of the suction pump **23** is adjusted in such a manner that the pressure Pr is within the target pressure range.

When the answer is Yes in step **203**, the procedure proceeds to step **205** in which the driving voltage V is stored in the memory as the first driving voltage V**1**.

Then, the procedure proceeds to step **206** in which the computer determines whether a negative-pressure-introducing period Tneg is less than the predetermined period T**1**. When the answer is Yes in step **206**, the procedure proceeds to step **207** in which the computer determines whether the pressure in the reference-pressure-detecting portion **26** is stable according to whether the variation speed of the pressure is slower than a predetermined speed. When the answer is No in step **207**, the procedure ends.

When the answer is No in step **206** or the answer is Yes in step **207**, the procedure proceeds to step **208** in which the pressure in the reference-pressure-detecting portion detected by the pressure sensor **27** is stored in the memory of ECU **31** as the reference pressure Pr.

(Defect Determination Process)

The defect determination process shown in FIG. **8** is a subroutine which is executed in step **104** of the main process shown in FIG. **6**. In step **301**, the computer determines whether the driving voltage V of the suction pump **23** is higher than an upper limit voltage Vhigh. When the driving voltage V is higher than the upper limit voltage Vhigh, the procedure proceeds to step **302** in which the computer determines the suction pump **23** or the reference-pressure-detecting portion **26** has a defect (for example, the characteristic of the suction pump **23** is dispersed toward the lower limit value).

When the answer is No in step **301**, the procedure proceeds to step **303** in which the computer determines whether the driving voltage V of the suction pump **23** is lower than a lower limit voltage Vlow. When the answer is Yes in step **303**, the procedure proceeds to step **304** in which the computer determines the suction pump **23** or the reference-pressure-detecting portion **26** has a defect (for example, the characteristic of the suction pump **23** is dispersed toward the upper limit value).

When the computer determines that the driving voltage V is within the normal range (Vlow≦V≦Vhigh), the computer determines the suction pump **23** and the reference-pressure-detecting portion **26** have no defect to end the procedure.

According to the first embodiment, since the driving voltage V of the suction pump **23** is adjusted in such manner that the pressure Pr is within the target pressure range, the negative pressure introducing condition can be made stable, so that the reference pressure Pr is always kept proper value to restrict a disperse of leak detection accuracy due to a disperse pf the reference pressure Pr.

Furthermore, since the suction pump **23** is driven at the first driving voltage V**1**, the negative pressure introducing condition is made stable. Thus, the leak detection can be conducted under proper negative pressure introducing condition, and the load applied to the fuel vapor purge system is restricted to enhance the durability of the fuel vapor purge system.

Besides, since the negative pressure introducing condition can be made stable with no affect of disperse of suction pump characteristic, a disperse of the leak detection period is restricted and a tolerance of the disperse of the suction pump characteristic is moderate.

According to the first embodiment, when the driving voltage V is adjusted, the computer determines whether the suction pump **2** and the reference-pressure-detecting portion **26** have a defect. Thus, the defect of the suction pump **23** and the like is early detected.

According to the first embodiment, since the suction pump **23** is used, even if a leak hole is generated in the fuel vapor purge system, the atmospheric air is introduced into the system through the leak hole and the fuel vapor hardly leaks toward the atmosphere through the leak hole. When the negative pressure is introduced, the amount of fuel vapor which is not adsorbed in the canister can be reduced.

Second Embodiment

Referring to FIGS. **9** to **12**, a second embodiment will be described hereinafter.

In a case of detecting a leak hole which corresponds to a second aperture of which diameter (for example, 0.6 mm) is different from that of the reference orifice (for example, 0.5 mm), the reference pressure Pr is corrected according to the diameter of the second aperture. Comparing the corrected reference pressure Pr with the pressure Pf in the fuel vapor purge system, it can be determined whether a leak hole corresponding to the second aperture exists.

According to the second embodiment, as shown in FIG. **9**, the first driving voltage V**1** is corrected according to the diameter of the second aperture to obtain a second driving voltage V**2**. The suction pump **23** is driven at the driving voltage V**2** when the pressure detecting process is conducted.

As shown in FIG. **10**, after the suction pump **23** is driven at the first driving voltage V**1** to detect the reference pressure Pr, the suction pump **23** is driven at the second driving voltage V**2** to detect the pressure Pf in the fuel vapor purge system. Comparing the reference pressure Pr with the pressure Pf, it is determined whether a leak hole corresponding to the second aperture exists.

Referring to FIG. **11**, a second-voltage calculation process will be described hereinafter.

In step **401**, a correction coefficient α corresponding to the second aperture is calculated based a correction coefficient table shown in FIG. **12**. According as the diameter of the second aperture increases, the correction coefficient α increases. In the case that the diameter of the second aperture is equal to the diameter of the reference orifice (for example, 0.5 mm), the correction coefficient α=1.

Then, the procedure proceeds to step **402** in which the second voltage V**2** is derived by correcting the first voltage V**1** with he correction efficient α.

$$V2=V1\times\alpha$$

According to the second embodiment, without changing the reference pressure Pr, a leak hole corresponding to the second aperture can be detected to enhance the accuracy of the leak detection.

In the first and second embodiments, the suction pump **23** is used. The suction pump **23** can be replaces by a discharge pump. In the first and second embodiments, the pressure sensor **27** is used to detect the reference pressure and the pressure in the fuel vapor purge system. Instead of the reference pressure and the pressure in the fuel vapor purge system, kinetic characteristic of the suction pump **23**, such as current, voltage, rotation speed, can be used, so that the pressure sensor **27** can be omitted.

The present invention is applied to not only the system in which the leak detection is conducted during engine is not running but also the system in which the leak detection is conducted during engine is running.

What is claimed is:

1. A leak detector for a fuel vapor purge system introducing a fuel vapor in a fuel tank into an intake pipe of an internal combustion engine, the leak detector comprising:
- a pressure-introducing-detecting apparatus including
  - a pressure introducing unit introducing a pressure into the fuel vapor purge system including the fuel tank;
  - a reference-pressure-detecting portion provided with a reference aperture having a predetermined inner diameter; and
  - a switching unit switching between a passage for introducing pressure into the reference-pressure-detecting portion and a passage for introducing pressure into the fuel vapor purge system; and
  - a leak determination unit detecting a reference pressure information representing a reference pressure adjusted by the reference aperture or correlated information of the reference pressure, the leak determination unit detecting a system pressure information representing a system pressure in the fuel vapor purge system or correlated information of the system pressure, the leak determination unit determining whether a leak exists by comparing the reference pressure information with the system pressure information,
  - wherein the leak determination unit adjusts a control value of the pressure introducing unit using the reference pressure information as a target condition to set a first control value when the reference pressure information satisfies the target condition, and thereafter drives the pressure introducing unit at the thus set first control value during a leak detecting operation.

2. The leak detector according to claim **1**, wherein
the leak determination unit (a) sets a second control value by correcting the first control value when a leak hole corresponding to a second aperture of diameter different from that of the reference aperture is detected, and (b) drives the pressure introducing unit at the second control value.

3. The leak detector according to claim **1**, wherein
the pressure introducing unit is a suction pump which introduces negative pressure into the fuel vapor purge system.

4. The leak detector according to claim **1**, wherein
the pressure introducing unit is a discharge pump which introduces positive pressure into the fuel vapor purge system.

5. The leak detector according to claim **1**, wherein
the leak determination unit determines whether the control value is within a predetermined range when the control value of the pressure introducing unit is adjusted in order to determine whether a pressure-introducing-detecting apparatus has a defect.

6. The leak detector according to claim **1**, wherein
a kinetic characteristic of the pressure introducing unit is utilized as the reference pressure information and the system pressure information.

7. A method for detecting leaks in a fuel vapor purge system disposed between a fuel tank and an intake pipe of an internal combustion engine, said method comprising:
- adjusting the drive power to a pump when connected with a reference orifice to achieve a target reference pressure and determining the corresponding drive power as a first control value;
- driving said pump with said first control value when connected with said fuel vapor purge system; and
- performing a leak check by comparing (a) information correlated with said target reference pressure with (b) information correlated with a pressure of said fuel vapor purge system.

8. A method as in claim **7** further comprising:
adjusting drive power to said pump from said first control value to a second control value to achieve said target reference pressure when a leak hole is detected having a diameter different from that of the reference orifice, said second control value being correlated to the leak hole size as compared to the reference orifice size.

9. A method as in claim **7** wherein
the pump is a suction pump which introduces negative pressure into the fuel vapor purge system.

10. A method as in claim **7** wherein
the pump is a discharge pump which introduces positive pressure into the fuel vapor purge system.

11. A method as in claim **7** wherein
if the adjusted control value is outside a predetermined range, the pump is determined to have a defect.

12. A method as in claim **7** wherein
a kinetic characteristic of the pump is utilized as (a) reference pressure information and (b) system pressure information.

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